Model Answers: Hard

1a

a) It is important that the isolation medium is at the same solute concentration as the spinach cells because...

- This prevents water from moving into / out of the chloroplasts by osmosis; [1 mark]
- Prevents damage to the chloroplast membranes / prevents the chloroplasts from bursting; [1 mark]

[Total: 2 marks]

Remember here that it is the activity of the chloroplasts that is being investigated so it doesn't matter if the plant cells themselves are damaged: in fact, it is likely that they may already have been damaged during the preparation of the chloroplast suspension. It is the chloroplast function that needs to be maintained: if they burst then all of the components that need to be close together for photosynthesis to occur will be dispersed and the reaction will not happen as normal.

1b

b) i) The purpose of tube **X** is to...

- Demonstrate that it is the presence of the chloroplasts (and not the isolation medium) that cause the colour change/reduction of DCPIP; [1 mark]

b) ii) The purpose of tube **Y** is to...

- Demonstrate that it is light that causes the colour change/reduction of DCPIP (and not the mixing together of the different components) **OR** demonstrate that light is required to cause the colour change / reduction of DCPIP; [1 mark]

b) iii) The purpose of tube **Z** is to...

- Show the colour of the tube in the absence of DCPIP / provide a reference for the point at which DCPIP has become colourless; [1 mark]

[Total: 3 marks]

When DCPIP is reduced its colour changes from deep blue to colourless. The light dependent reactions cause electrons to be released, reducing DCPIP to its colourless form.

Tubes **X** and **Y** are control tubes showing that it is certain variables that are causing the colour change and not others.

Tube **Z** is a reference tube. Chloroplasts in suspension have their own colour, a scientist will not observe a colourless tube but a green one; tube **Z** shows the exact shade of green at which DCPIP has become colourless.

1c
c) The results shown in Fig. 1 are due to...

- As light intensity increases / distance between the lamp and tube decreases photoactivation/photolysis occurs faster / more / at a higher rate; [1 mark]
- More electrons pass to the electron transport chain; [1 mark]
- These electrons pass to DCPIP instead of to NADP (causing it to become colourless); [1 mark]

[Total: 3 marks]
1d
d) The farmer was advised not to use ammonium hydroxide weedkiller on their crop fields because...

- The light dependent reactions / production of reduced NADP/NADPH occurs / will be inhibited (by ammonium hydroxide) in all plants; [1 mark]
- (Ammonium hydroxide) will kill the crop plants as well as the weeds; [1 mark]

[Total: 2 marks]

Ammonium hydroxide is highly toxic to all living cells, and prevents the formation of NADPH in photosynthesis; it is therefore not a good choice of weedkiller in any situation where some organisms need to be kept alive. It might work well on a pavement or a patio, but would kill off any desired plants/crops along with the weeds in a field or flower bed.
2a
a) Radioactively labelled carbon dioxide is fixed into radioactive substances in the leaves of the plant in Fig.1 by...

Any **three** of the following:

- (Radioactively labelled) carbon dioxide diffuses into plant leaves through the stomata; [1 mark]
- Carbon dioxide is (fixed by being) combined with RuBP/ribulose bisphosphate; [1 mark]

- (The reaction) is catalysed by rubisco/ribulose bisphosphate carboxylase; [1 mark]
- The resulting (unstable, 6C) compound splits into two molecules of (3C) GP/glycerate-3-phosphate; [1 mark]

[Total: 3 marks]

Carbon fixation is the removal of carbon from the atmosphere and its incorporation into the biological molecules of the plant. Your answer should therefore include the stages by which the carbon dioxide leaves the air surrounding the plant and becomes a stable molecules inside the leaf.

2b

b) The results shown in Fig. 1 when the plant is moved into the dark are due to...

Any **four** of the following:

- The light dependent reactions / photophosphorylation stops; [1 mark]
- The supply of ATP **AND** NADPH/reduced NADP (to the Calvin cycle) stops; [1 mark]
- RuBP continues to be converted into GP; [1 mark]
- GP cannot be converted into TP/triose phosphate (so GP builds up); [1 mark]
- TP cannot be converted into RuBP / RuBP cannot be regenerated (so RuBP levels drop); [1 mark]

[Total: 4 marks]

In the absence of light, the light-dependent reactions can no longer occur so ATP and NADPH are not produced for the Calvin cycle. The parts of the Calvin cycle that do not require these products continue, so RuBP is converted into GP when carbon dioxide is fixed, but this GP cannot be converted into TP, as this process requires ATP and NADPH. GP builds up inside the leaf as a result of this. The conversion of TP into RuBP also stops as the supply of TP will drop and there is no ATP to power the process, so RuBP levels decrease.

2c

c) Photorespiration reduces the efficiency of photosynthesis because...

Any **two** of the following:

- No TP / hexose sugars are produced; [1 mark]
- Carbon dioxide is lost rather than fixed; [1 mark]
- Less GP enters the Calvin cycle / only 1 GP molecule enters the Calvin cycle rather than 2; [1 mark]

- More ATP will be needed (to transfer molecules between different organelles / fuel the many chemical reactions); [1 mark]

[Total: 2 marks]

Even though you are not required to have knowledge of photorespiration, you should still be able to apply your knowledge of the Calvin cycle to a question like this. Consider the important elements of the Calvin cycle (i.e. that it fixes carbon into GP and produces hexose sugars) and look at how these elements are affected by photorespiration; less GP is produced, carbon dioxide is released, and no TP is produced at all. You can also look at the additional information provided here, such as the idea that the process occurs across several organelles and contains many more chemical reactions; these features suggest that more ATP will be required, even if this isn't directly stated in the diagram.

2d
d) The enzyme (rubisco) could be improved by...

Any **two** of the following:

- Genetic engineering/modification / altering the base sequence to alter the gene for the enzyme (rubisco); [1 mark]
- Altering the active site of the enzyme to make it more specific to carbon dioxide / no longer complementary to oxygen; [1 mark]
- Adding a non-competitive inhibitor that changes the active site shape (so that it no longer binds to oxygen); [1 mark]
- Carry out screening/testing to find plant species/varieties with a more efficient enzyme; [1 mark]
- Carry out selective breeding to increase the frequency of the efficient enzyme in a plant variety; [1 mark]

[Total: 2 marks]

While you are not expected to know exactly how the improvement of the enzyme rubisco could be achieved, your knowledge of enzyme structure and function should allow you to make some good suggestions here. Enzymes are proteins so their structure can be changed by altering the base sequence of the genes that code for them. Non-competitive inhibitors can also alter the structure of an active site. The active site would need to be altered in such a way that it is more complementary/specific to carbon dioxide and less complementary to oxygen. An alternative to altering the existing enzyme would be searching for a more efficient version of the enzyme among species and varieties that already exist. Selective breeding could be used to increase the frequency of the efficient enzyme in a particular variety, e.g. an important crop.